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Types of geoecological research and areas of their application

E Baryshev¹, K Shmakova¹ and N Yakshina¹

¹Ural Federal University, 19 Mira str, 620002, Ekaterinburg, Russia

E-mail: e.e.baryshev@urfu.ru

Abstract. Planning for the environmental management, construction, as well as forecasting the impact of human activity on the environment, should be carried out based on the provisions of geoecology, which combines relationships in geographical, biological (ecological) and social-production systems. In this case, a systematic approach, as well as knowledge of the links between different systems, will allow us to simulate the level of human impact on the environment and calculate the optimal degree of intervention in its structure. Modern methods of geoecological studies used to assess the impact of human economic activity on the environment are considered, a comparison of geoecological mapping in Russian and foreign studies is carried out, the main stages necessary for conducting geoecological studies are indicated.

1. Introduction

In Russia, the use of the term “geoecology” began in the 1970s, after it was mentioned by the well-known Soviet geographer V.B. Sochava, in the context of applied geography as a special direction necessary for the effective use of geographic concepts in practice [1]. As a separate scientific discipline geoecology was formed only in the early 90s of the XX century.

However, this term has not yet received a clear and generally accepted definition. Within the framework of a "geoecology" broad understanding there are many diverse scientific directions and practical problems.

Due to the fact that geoecology covers diverse aspects of society and nature interaction, there is a different interpretation of its subject, object and content; the issues range of geoecological research is not defined; there is no generally accepted methodology and terminological base. The tasks of geoecology are also formulated in different ways, often very heterogeneous and mainly come down to the study of negative anthropogenic impacts on the environment.

All this leads to difficulties in the use of geoecological studies to solve problems associated with environmental management.

2. Geoecology directions

The term "geoecology" was introduced into scientific circulation by the German scientist, physicist and geographer Karl Troll in 1939y. to denote the spatial interaction of natural phenomena and the relationship between phenomena within a particular ecosystem. His brother, the botanist Wilhelm Troll, borrowed the term “geoecology” and applied it in his field of biology as a section of ecology that studies the ecology of Earth’s landscapes. This was meant to study the life of living organisms’



communities, peculiar to certain types of natural systems (lakes, forests, tundra, etc.). Thus, the term "geoecology" became the property of two sciences at once - geography and biology.

In connection with this so far released two major trends in "geoecology" term understanding subject, its goals and objectives of the discipline:

- Geoecology is considered as the ecology of the geological environment. With this approach, geoecology studies the natural relationships (direct and inverse) of the geological environment with other natural environment components - the atmosphere, hydrosphere, biosphere; assesses the impact of human activities in all its diverse manifestations. In this context, geoecology is considered as a science at the junction of geology, geochemistry, biology and ecology.

- Geoecology is treated as a science that studies the interaction of geographical, biological (ecological) and social and production systems. In this case, geoecology studies the ecological aspects of environmental management, the relationship between human being and nature, it is characterized by the active use of the systemic and synergistic paradigms, the evolutionary approach and is considered as a scientific discipline at the junction of geography and ecology [2].

There are two meanings indicating different interpretations in geo-ecology. Here are some of them:

- "Geoecology as the geography section explores high hierarchical levels ecosystems (geoecosystems) - up to and including the biosphere." (Реймерс Н.Ф., 1990).

- "Geoecology is a science that integrates knowledge in the field of geography and ecology" (Алхименко А.П., Степанов В.Н., 1990).

- "Geoecology is the science of modern landscapes (natural, transformed and created by human being), as well as the geological environment, the ways and possibilities of using natural resources under environmental constraints during socio-economic development" (Горшков С.П., 1992).

- "Geoecology is the science of the modern living biosphere interaction of the (including humans) with the modern geographical environment created by the large biosphere (including biogenic inert media and anthropogenesis - the impact on the composition of the substance, its information structure and energy fields)" (Федоров Б.Г., Петров Е.Ю., 1993).

- "Geoecology is a new scientific direction of geology, which studies the structure, composition and properties of the geological environment as a component of the ecosystem" (Вартанян Г.С., 1991).

- "Geoecology is a science that studies the characteristics of geological and mining engineering factors impact on nature and man" (Бент О.И., 1992).

- "Geoecology is a geological science that uses many laws of adjacent sciences and is aimed at solving environmental problems of different levels and scale, manifested in the lithosphere or associated with lithospheric processes" (Исаев Е.Н., Клубов С.В., Прозоров Л.Л., 1994).

The International Geological Congress, held in 1989 in Washington, where the Minister of Geology of the USSR, Ye.A. Kozlovsky made a report: "Geoecology - New Scientific Direction", could be taken as a point of reference, which united various areas of geoecology. The report noted that "geoecology is a direction formed at the junction of geology and ecology."

In this regard, geoecology object research means the geoecological system, which includes such elements as flora and fauna (human beings included), the geological environment and man-made objects. The main task is to study and assess changes in the geological environment as a result of human activities. Thus, the basic geoecology provisions as a discipline may include:

- The geoecology is based on three natural sciences: geology, biology and geography, and one social discipline - economics.

- The study of natural processes and phenomena affecting the biosphere, are studied equally with anthropogenic changes.

- Anthropogenic (man-made) processes are considered in a series of biosphere as a manifestation of the human population, which has certain specific features. A person is considered as a biosocial being in which two essences are combined - biological (natural) and social (public).

3. Types of geoenvironmental studies used in various types of territory economic developments

Geoecological studies are aimed at resolving issues of interactions between nature and society related to the geoecological assessment of the economic activity consequences, the quality of the environment and the development of environmental management recommendations.

Geoecological studies operate on the following set of methods: geological, geochemical, geophysical, hydrogeological, geomorphological, geocryological. As a result of the obtained data interpretation, phenomena, processes, properties and dependencies are established. They act as geoecological factors, so reflect certain interaction aspects of the lithosphere, atmosphere, hydrosphere with the biosphere.

Geological studies include those aimed at studying the properties of the geological environment, the petrological nature of rocks, and geodynamic processes. The petrological properties of rocks are due to their mineral and chemical composition, structure and texture, occurrence conditions and the changes that they undergo in earth's crust depths and on its surface. Geodynamic processes occurring both inside the crust and on its surface are expressed in the form of tectonic movements, seismic and volcanic processes.

Petrological rocks properties in combination with geodynamic processes determine the place and time of occurrence, as well as the nature of geoecological factors. Practice shows that the lack or poor knowledge of the geological environment state often leads to disastrous consequences. A striking example of this are large-scale damage during earthquakes. For example, underestimation of seismic Northern Sakhalin activity led to the death of 2040 inhabitants Neftegorsk from 3197, lived there before the earthquake in 1995.

Tragic situations also arise during the underground and surface mine works, especially, when previously unknown and not mapped in time faults and floods make themselves known.

On the basis of geological studies, they reveal features of geological processes manifestation, outline geopathogenic zones, determine their nature and degree of functioning [3].

Geochemical studies study the distribution of chemical elements or chemical compounds in rocks, atmosphere, natural waters, vegetation, animals. In recent years, they are widely used in the practice of geoecological work. Particularly special geochemical surveys techniques and mapping of certain areas are attractive, including urban agglomerations. They are carried out in order to identify places of elevated concentrations of chemical elements, delineate and assess the magnitude of geochemical anomalies, and primarily to determine the distribution contours of toxic and radioactive elements.

According to [4], the main issues addressed in the framework of geochemical studies should be the following:

- differentiation of geochemical anomalies on geogenic and technogenic with environmental assessment. This will provide an opportunity of more reliably sources determination of geochemical pollution and their size;
- complex geochemical studies on modern sampling of waters, soils and bottom sediments, which make it possible to find out most reliably main geochemical features of the studied territory from the results of geochemical sampling;
- using the analysis results of samples taken during regional geochemical surveys to assess the state of the environment;
- complex nature work expediency on the study of the environment with the involvement of specialists of the appropriate profile.

Using geophysical investigations, we can study the distribution of natural or artificial physical fields - gravitational, magnetic, electromagnetic, radiation, thermal, etc. The location of these fields is established using geophysical equipment, which has a high measurement accuracy and makes it possible to identify even the weakest changes in the fields.

Geophysical research methods allow to: study the impact degree of remote underground nuclear explosions and the explosions effect during underground mineral deposits on rock strata mining; determine the seismogenic regime of reservoirs and the impact degree exerted on the surface of the

lithosphere during the large rockets launch; solve the problem of warning in the underground mining of rock bursts, collapses, flooding.

Radiometric (radioactive) methods based on the identification and study of various objects radioactivity occupy a special place in the series of geophysical studies. Elevated concentrations of radioactive elements in natural objects are associated both with natural sources, for example, granitoid massifs, and with human activity. Based on such measurements, zoning of the Russian territory according to the danger degree caused by natural radioactive elements, as well as the radiation hazard associated with human activity is being carried out.

Hydrogeological studies are aimed at studying the conditions of occurrence, regime, physical and chemical properties of groundwater, their relationship with rocks, atmosphere and surface waters. It is known that many processes that occur on the earth's surface and have a significant impact on the environment largely depends on the occurrence characteristics and the groundwater regime.

Among the urgent problems of groundwater study for household purposes are the quality control and forecast of its changes, as well as the development of practical recommendations for the preservation and improvement of this quality. In this regard, permissible contaminating loads on groundwater of various geochemical types are the most promising calculations, and solving the quality managing problem of groundwater directly in aquifers [5, 6].

With the help of geocryological research methods, we study the structure, composition, properties and distribution of permafrost soils and strata of the earth's crust, as well as the processes associated with their freezing and thawing [7].

Permafrost priming, soils and strata occupy about 20% of the land surface. They are a significant obstacle to the human activities implementation, ranging from laying highways to the construction of industrial and residential buildings. The main geocryocology methodological principles are the monitoring and analysis of geocryosystems evolution under the external conditions influence of their existence and development.

Using geomorphological methods, we can study all the variety of relief forms that arise as a result of endogenous and exogenous processes combined influence on the geological environment. Along with the natural processes the relief certain forms are created as a result of human activities.

To provide geoecological studies with reliable data, various methods are currently being used to obtain them.

Using electrical survey methods, positive results were obtained in studying the pollution of groundwater and mapping filtration flows at great depths [8]. Seismoacoustic methods have proven themselves in the study of endogenous and exogenous processes, geocryological conditions and in the mapping of underground ice. Seismic profiling makes it possible to investigate the geophysical fields nature and study the tectonic disturbances characteristics in the water area of reservoirs and lake reservoirs. Seismoacoustic and electrical survey methods help to establish the spatial distribution of sediments, karst-suffusion processes and the latest tectonic movements. These methods are especially important while studying induced seismicity.

Gravitational methods allow to locate and trace active faults in the area.

Aerospace methods of studying the earth's surface, conducted over the past decades, have made a significant contribution to geological science. The main advantages of this method are the information accuracy and objectivity, obtaining images possibility of any generalization degree, obtaining information efficiency and the external geospheres of the Earth simultaneously studying possibility.

The most effective means of aerospace sensing are photographic systems that have high resolution and the ability to obtain stereo effect. Space information is of paramount importance for the rapid detection of catastrophic natural and anthropogenic phenomena. With its help, it is possible to detect: the nature and consequences of large earthquakes or volcanic eruptions, the development of landslide phenomena, discharges of hazardous waste into the waters of the World Ocean, tanker accidents, and large-scale emissions into the atmosphere of harmful and toxic substances. Due to the fact that observations are conducted on waves of various lengths — in the optical, infrared and radio wave ranges, it is possible to observe the earth's surface not only in a natural image, but also to consider its

thermal field with temperature anomalies and to obtain high-quality images regardless of the time of day and sizes of clouds.

Aerogamma-spectrometric and thermal methods acquired great importance for geoecological studies. They turned out to be especially effective for detecting and controlling pollution of water areas, spontaneous combustion processes in landfills and waste heaps, forest fires, underground peat fires and combustible minerals.

4. Conducting geoecological researches in Russia

Despite the fact that in the process of geological research and during mining geologists paid close attention to the state of the environment, for a long time special geoecological studies were not conducted. Highlighting the use of applied geochemistry works, which can be considered a prototype of geoecological studies, appeared only in the 80s of the 20th century.

In 1972, the first maps of USSR landscape-geochemical zoning were published, and were used to predict the influence of technogenesis. In 1979, a map of landscape and geochemical zoning of the Nonchernozem Zone was prepared. It is the publication of these maps that can be considered as the beginning of special geoecological studies.

One of the first works in the field of regional geoecological mapping can be considered a series of engineering geological maps on a scale of 1: 500,000 published in 1990. They were compiled by Moscow State University. M.V. Lomonosov Geological Faculty team under the leadership of academician E.M. Sergeev.

In the development of geoecological problems in the framework of hydrogeology and engineering geology, the leading role belongs to the Russian Research Institute of Hydrogeology and Engineering Geology (RRIHEG, Moscow). This team made a survey map of the geological environment state and technogenic changes on a scale of 1: 5,000,000 in 1983. It identifies the types of geological environment taking into account landscape-climatic factors, shows the structure of quaternary sediments and reflects the territories predisposition to the occurrence or activation of natural or man-made geological processes, shows the features of these processes and their intensity, changes in the underground hydrosphere, local processes in large cities; the features of groundwater pollution are reflected.

From 1964 to 1988, a series of hydrogeological maps of the European part of the USSR on a scale of 1: 500,000 was compiled by the staff of RRIHEG. This series includes two maps of geoecological content: a man-made changes map in the hydrosphere and security and pollution levels map of groundwater. Some geoecological parameters were reflected on the map of hydrogeological and ameliorative zoning. The main object of mapping was the natural-man-made systems, selected based on the types of geological environment and types of man-made systems.

In 1990, team of the Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements (IMCCRE, Moscow), Russian Geological Research Institute. A.P. Karpinsky (RGRI, St. Petersburg) and the Far-Eastern Scientific Research Institute of Mineral Resources (FESRIMR, Khabarovsk) introduced the territory multipurpose mapping concept of the USSR on a scale of 1: 1,000,000, 1: 200,000, and 1 : 50,000. Ecological-geochemical mapping has been included in studies of this kind. In this concept, for the first time, a hierarchical approach was applied to the objects of study and interpretation of various origins geochemical and geophysical fields. A new method of mapping was proposed based on preliminary multifactor zoning of territories.

From the 1991 y. many production organizations and scientific geological institutions began to develop technology for multi-purpose geochemical and geoecological mapping at six polygons in Russia (Kola, Moscow, Altai, Baikal, East-Zabaykalsky and Primorsky).

Geoecological work was to be carried out according to a unified program that coordinated and integrated multi-purpose research for all natural environments. In addition to geoenvironmental programs of national importance, some other programs of national importance were previously developed and were at the initial stage: 'Chernobyl', 'Aral', 'Arctic', 'Siberia', etc.

5. Differences in geoecological mapping in Russian and foreign studies

There are certain differences in the concept of geoecological mapping in Russia and in a number of other countries (Germany, Norway, Spain). The main one is that in Russia there is a clear delineation of research objects between departments. Planning materials are still created by groups of specialists and are reduced to the characteristics of the region only. Accordingly, plans for building up or developing new territories are limited by the characteristics of the region and take into account only socio-economic conditions and infrastructure features, and the possible risks are practically not taken into account in projects or development strategies.

However, for a holistic understanding of socio-ecological-economic problems, it is necessary to take into account territorial peculiarities that affect the sustainability of the geological environment to increasing pressures, such as water supply, water disposal, waste disposal, etc. In addition, for practical purposes, the nature of the links acting in the natural system is of great importance, which can only be identified through an anthropogenic comprehensive study impact on the environment.

In the above-mentioned countries, environmental studies are carried out comprehensively and taking into account economic factors. The term “geopotential” is widely used. In particular, I.D. Becker-Platin and M. Dorn, suggest using the concept of geopotential mapping. This concept in the foreign researcher’s interpretation is very close to the Russian concept of “geological environment”, which takes into account the economic value of its individual components (soil, groundwater, minerals).

The geoecological research final stage is the risk maps compilation for the territories development. Such maps give an idea of negative processes nature arising in the construction and operation of mineral deposits and in the other economic activity types process.

6. Results and discussions

Based on geoecology positions in order to conduct environmental management and forecasting the degree of the human activities impact on the environment following research levels should be carried out:

- base maps compilation, including a geological map showing hydrodynamic processes and the characteristics of rocks, as well as a soil map indicating the distribution of chemical elements and compounds in the soil;
- special maps compilation taking into account regional peculiarities — a hydrogeological map, indicating the conditions of occurrence, regime, physical and chemical groundwater properties; mineral resources maps, with an indication of minerals depth; maps on soil characteristics, agricultural productivity, forest cover, etc.;
- appraisal maps compilation — reserve territories maps for mining; groundwater use maps, etc.;
- potential land use mapping in terms of geopotential that allow strictly scientifically to plan commercial facilities placement by taking into account environmental constraints.

Based on such studies, it is possible to develop various versions of common situations models that will follow after the projected transformations. And to choose the best option in the end bearing in mind the environmental management problem in general.

7. Conclusions

The following conclusions can be drawn from the researches.

At present, the country’s transition from consumer resources use to holistic socio-ecological-economic development has matured by taking into account regional characteristics, scale and diversity of natural resource potential and environmental management. For this purpose, in territorial planning it is necessary to apply a geoecological assessment, which makes it possible to optimize the use of natural potentials.

Based on the provisions of geosystems developed theory by Soviet and Russian scientists, using available to modern researchers various modern geoecological research methods, and taking into account the positions of a systematic approach to resource management solving problems, it is

possible to assess the current state of natural resources and geoecosystems, to forecast their qualitative and quantitative changes, assessment of various sectors production impact on the environment and to develop recommendations for improving the process of environmental management and optimizing the environment.

With the help of geoecological studies, it is possible to carry out an economic activities environmental assessment in the investment documentation development (sectoral and territorial development programs, programs for the integrated use and natural resources protection, engineering protection schemes for the territory, regional planning schemes), urban planning documentation (settlements general plans development, detailed planning projects), project documentation (projects and working documentation development for building constructions and engineering structures, land use projects) and for the environmental monitoring organization.

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